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108. The γ -alumina catalyst support material of claim 107 wherein said acidic aqueous solution used in step (a) consists essentially of water and nitric acid and has a pH in the range of from about 3 to about 1.

Remarks

The Examiner's Office Action mailed April 10, 2002 has been reviewed. In this response, claims 67-76 and 86-88 are cancelled and replaced with new claims 89-108. Applicants request re-examination and reconsideration of the application in view of these amendments and further in view of the following remarks.

New claims 89-100 call for a cobalt-on- γ -alumina catalyst having improved attrition resistance for Fischer-Tropsch hydrocarbon synthesis. The cobalt-on- γ -alumina catalyst is produced by a method comprising steps of: (a) calcining boehmite material at a temperature and for a time effective to convert at least most of the boehmite material to a γ -alumina support material; (b) treating the γ -alumina support material with an acidic aqueous solution; and then (c) forming the cobalt-on- γ -alumina catalyst by depositing cobalt on the γ -alumina support in an amount effective to catalyze the Fischer-Tropsch hydrocarbon synthesis. The γ -alumina support material is treated with the acidic aqueous solution in step (b), prior to depositing cobalt thereon in step (c), at an acidity level effective for increasing the attrition resistance of the cobalt-on- γ -alumina catalyst for Fischer-Tropsch hydrocarbon synthesis.

Claim 90 requires that the γ -alumina support be treated with the acidic aqueous solution at an acidity level and in an amount effective for increasing the attrition resistance of the cobalt-on- γ -

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alumina catalyst for Fischer-Tropsch hydrocarbon synthesis in a high agitation reaction system.

Claim 91 states that the high agitation reaction system is a slurry bubble column reactor.

Claim 92 states that the acidic aqueous solution has a pH of not more than 5. Claim 93 provides that the γ -alumina support material produced and used in this invention have an average particle size of not more than 90 microns.

Claim 94 states that the acidic solution comprises water or nitric acid. Claim 95 provides that the process for forming the cobalt-on-alumina catalyst comprises the further step, after treating the calcined γ -alumina support with the acidic aqueous solution in step (b) and prior to depositing cobalt thereon in step (c), of recalcining the γ -alumina support material at a temperature such that at least most of the support material remains in γ -alumina form. Claim 96 requires that the boehmite material be calcined in step (a) at a temperature in the range of from about 350° C to about 700° C. Claim 97 states that the γ -alumina support material is recalcined, after step (b), at a temperature of about 350° C. Claim 98 provides that the boehmite material is originally calcined in step (a) at a temperature of about 500° C.

Finally, claim 99 provides that the pH of the acidic aqueous solution is in the range of from about 3 to about 1 and claim 100 states that the boehmite material used is a spray-dried, synthetic boehmite.

Claims 101-106 call for a γ -alumina catalyst support having improved attrition resistance for Fischer-Tropsch hydrocarbon synthesis. Claim 101 provides that the γ -alumina support is produced by a method comprising the steps, prior to adding any catalytic material thereto, of: (a) calcining

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boehmite at a temperature and for a time effective to convert at least most of the boehmite material to a particulate γ -alumina support material having an average particle size of not more than 90 microns; (b) treating the γ -alumina support material with an acidic aqueous solution comprising water and nitric acid at a pH of not more than 5 and in an amount effective for increasing the attrition resistance of the γ -alumina support for Fischer-Tropsch hydrocarbon synthesis; and then (c) recalcining the γ -alumina support material, prior to adding any catalytic material thereto, at a temperature such that at least most of the support material remains in γ -alumina form. Claims 102-106 depend from claim 101 and are similar to dependent claims 90, 91, 96, 97, 99, and 100 described above.

Claims 107 and 108 call for a γ -alumina support material having improved attrition resistance produced by a method comprising the steps of: (a) treating a particulate γ -alumina material with an acidic aqueous solution comprising water and nitric acid at a pH of not more than 5 and then (b) calcining the particulate γ -alumina material at about 350°C prior to adding any catalytic material thereto. Claim 108 further provides that the acidic aqueous solution used in step (a) consists essentially of water and nitric acid and has a pH in the range of from about 3 to about 1.

Applicants' original claims were rejected under 35 U.S.C. § 102(b) and/or 35 U.S.C. § 103(a) in view of U.S. Patent No. 4,315,839, issued to Bouge, et al. In contrast to Applicants' inventive Fischer-Tropsch cobalt catalyst and γ -alumina support therefor, Bouge et al, disclose only the preparation of very large (3.5 - 4 mm (Col. 13:44-45)) spheroidal alumina particles having bifold porosity for use in dehydration, hydrosulfurization, hydrodenitrofication, desulfurization,

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dehydrohalogenation, reforming, cracking hydrocracking, hydrogenation, dehydrogenation, dehydrocyclization, oxidation, reduction and Claus reaction systems and in catalytic converters for engine exhaust systems. (Col. 11: 16-41).

The bifold particles disclosed by Bouge, et al. are prepared by mixing an aqueous suspension of ultrafine or pseudo boehmite with spheroidal alumina particles at a pH of less than 7.5 (preferably between 3 and 7 and most preferably between 4 and 7). The mixture is then prilled and gelled, followed by drying and then calcining at a temperature of from 550 to 1100°C (preferably about 950°C). Contrary to the requirements of Applicants' claims, the boehmite material used by Bouge et al. is not calcined prior to being placed in aqueous suspension and mixed with the spheroidal alumina particulate material. In addition, Bouge, et al. neither disclose nor suggest the formation of a particulate pseudo-boehmite material by spray drying.

Moreover, Bouge, et al. expressly teach that, if it is desired to obtain high thermal stability and to ensure sufficient attrition resistance to prevent significant shrinkage and loss, the spheroidal alumina particles used in the Bouge, et al. mixture should be calcined at high temperature so that essentially all of the alumina material is converted to the delta and/or theta form. (See Col. 8:26-47). In addition, in order to obtain "high performance characteristics" and "thermal stability," Bouge, et al. also teach that, in the last stage of the formation process, the ultimate Bouge, et al. product should be calcined at high temperature (550°-1100° C, preferably 950°C) such that essentially all of the alumina contained therein will be in delta and/or theta form. (Col. 11: 16-41 and Col. 13: 11-16).

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Applicants further note that the relevant mechanisms producing attrition losses for the very large (3.5-4 mm), bifold spheroidal material produced by Bouge, et al. are different from those affecting the smaller material (preferably not more than 90 microns) produced by Applicants for Fischer-Tropsch hydrocarbon synthesis in slurry bubble column and other high agitation reaction systems. In high agitation systems, the particles move about, collide, and interact. In contrast, large materials of the type produced by Bouge, et al. are designed for use in fixed bed reaction systems wherein the primary stress placed on the material is the weight of the catalyst bed itself. Consequently, attrition resistance for the large Bouge, et al. material is defined and measured in terms of "rupture strength" (see Col. 10: 58-66).

Thus, Bouge, et al. neither disclose nor suggest several key features called for in Applicants' claims. Examples of such features include:

1. A cobalt-on- γ -alumina catalyst comprising a γ -alumina support having a catalytically effective amount of cobalt deposited thereon for Fischer-Tropsch hydrocarbon synthesis.
2. A cobalt-on- γ -alumina catalyst of this type having improved attrition resistance for Fischer-Tropsch hydrocarbon synthesis. (Claim 89)
3. Calcining a boehmite material (preferably a spray-dried synthetic boehmite material) for a time and at a temperature effective to convert at least most of the boehmite material to a γ -alumina support material. (Claims 89, 100, 101, and 105)

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4. Treating a γ -alumina support material of this type, prior adding any catalytic material thereto, with an acidic aqueous solution at an acidity level and in an amount effective for increasing the attrition resistance of the γ -alumina support material and/or the cobalt-on- γ -alumina catalyst produced therefrom for Fischer-Tropsch hydrocarbon synthesis. (Claims 89 and 101)
5. A γ -alumina support and/or a cobalt-on- γ -alumina catalyst of this type which is treated with the acidic aqueous solution in a manner effective for obtaining increased attrition resistance for Fischer-Tropsch hydrocarbon synthesis in a slurry bubble column reactor or other high agitation reaction system. (Claims 90, 91, 102, and 103)
6. A γ -alumina support and cobalt-on- γ -alumina catalyst of this type wherein the γ -alumina support material has an average particle size of not more than 90 microns. (Claims 93 and 101)
7. Recalcining the γ -alumina support material, after treatment with the acidic aqueous solution and prior to adding any catalytic material thereto, at a temperature such that at least most of the support material remains in γ -alumina form. (Claims 95 and 101)
8. A γ -alumina support material and cobalt-on- γ -alumina catalyst of this type wherein the γ -alumina support is recalcined at a temperature of about 350°C. (Claims 97 and 106)

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9. Treating the γ -alumina support material with an acidic aqueous solution at a pH in the range of from about 3 to about 1. (Claims 99, 104, and 108)

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In view of the above, Applicants respectfully submit that all of Applicants' remaining claims 89-108 are in condition for allowance. Applicants therefore request that all of the examiner's rejections be removed and that the examiner allow claims 89-108.

This paper is intended to constitute a complete response to the Examiner's Office Action mailed April 10, 2002.

Respectfully submitted,

 7/10/02

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